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FARMERS' BULLETIN No. 1637

SUGAR-BEET CULTURE *in the* HUMID AREA OF THE UNITED STATES

THIS BULLETIN outlines the practices found successful in sugar-beet growing in those areas of the United States where beets are grown dependent upon natural rainfall without recourse to irrigation.

The area adapted to sugar beets is more or less restricted to districts where soil and climatic conditions are especially favorable. An adequate supply of moisture, especially during the growing season, soil of a proper type, and a long, moderately cool growing season are essential. The adaptability of the sugar beet has permitted its culture on a wide range of soils, but the more satisfactory yields are generally secured on the heavier types. The soil should have good depth, fairly high organic content, adequate drainage, high moisture-holding capacity, and a favorable soil reaction. When properly grown, the sugar beet fits well into a rotation, furnishes a high return, and is valuable for the proper maintenance of soil fertility and tilth.

In the culture of sugar beets intensive measures are necessary. Careful preparation of the soil for the seed bed, proper planting practices, abundant use of manure and fertilizers, and frequent cultivations are essential in securing satisfactory returns.

Weed control is extremely important, especially in the early half of the season when the beet plants are small and may be injured by their rapidly growing weed competitors.

The sugar beet furnishes, in the form of beet tops and beet pulp, a valuable source of feeding material for use on the farm, and these may properly be considered as additional returns from the beet crop.

This bulletin supersedes Farmers' Bulletin No. 568, Sugar-Beet Growing Under Humid Conditions.

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SUGAR-BEET CULTURE IN THE HUMID AREA OF THE UNITED STATES[1]

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INTRODUCTION

THE SUGAR-BEET PLANT is cultivated primarily for the sugar that is extracted from its root. The sugar is formed in the leaves from water and carbon dioxide through the agency of chlorophyll and sunlight, as simple sugars. During the growing season much of this sugar is used in the growth processes of the plant, but as the growth is retarded in the latter part of the growing period the simple sugar formed is stored in the roots as sucrose. The value of the crop depends upon the weight of the roots produced per acre and their sucrose content. Because of its great adaptability the sugar-beet crop may be grown under very different conditions in a wide range of territory, but for successful production on account of the expense incident to the production of this intensive crop, the yields must be sufficiently high for the crop to compete successfully with the other crops grown, and the sucrose content must be sufficient to permit the profitable manufacture of sugar.

The commercial sugar-beet crop is harvested at or near the end of the period of vegetative growth when the roots have reached their maximum size for that period, and the sucrose content is at the highest point. In most of the sugar-beet districts this is at the end of the first season, for selection has caused the sugar-beet plant to assume the habits of a biennial. That is, when permitted to complete its life cycle, it makes its vegetative growth and stores sugar during the first season, remains dormant over winter, and then resumes growth and produces seed during the second season. The

[1] The investigations upon which this publication is based were conducted at the Michigan Agricultural Experiment Station, East Lansing, Mich., under a cooperative agreement between the Office of Sugar Plants of the Bureau of Plant Industry, United States Department of Agriculture, and the farm-crops section of the Michigan Agricultural Experiment Station. This work, begun in 1923, for the first season was under the direction of E. C. Cormany, of the staff of the Michigan station. All chemical analyses in these investigations were made by O. B. Winter, research associate chemist, chemistry section of the Michigan station.

roots may increase in size during the second season, or the period of seed production, but they generally become very fibrous or woody and the sucrose content is usually reduced to such a point that they are unfit for manufacturing purposes.

SUGAR-BEET AREA IN THE UNITED STATES

From the standpoint of sugar-beet production, the United States may be divided into three fairly distinct areas by differences in the climatic or cultural conditions. These are: (1) The humid area, located in the North Central States; (2) the Mountain States area; and (3) the Pacific coast area. About 30 per cent of the total acreage of sugar beets produced in the United States is found in the humid area, about 60 per cent in the Mountain States area, and about 10 per cent in the Pacific coast area. In 1929 the total area devoted to this crop was approximately 717,000 acres.

The humid area comprises the States of Michigan, Ohio, Indiana. Wisconsin, Minnesota, Iowa, Illinois, and part of Nebraska. In this area the sugar beet is grown without the aid of irrigation. The production of the crop is not general over the whole area but is restricted to fairly definite districts where the soil and other conditions are exceptionally favorable.

CLIMATIC ADAPTATION

The sugar-beet crop requires an adequate supply of moisture during the growing season for successful production. In the humid area nearly half of the total annual precipitation normally comes during the months of the growing season, from May to September, inclusive. The quantity of water required by the sugar-beet crop for continuous growth depends almost entirely upon the amount of foliage; and while the precipitation during the early part of the growing season in these districts is probably more than actually required by the growing crop, the quantity normally received during August and September is not likely to exceed what the crop can use. However, great seasonal variations occur in all the sugar-beet growing districts. During October and November, the harvesting period in the humid area, the precipitation is usually much less than during the growing period. On the whole, the greatest success is attained in a season in which the rainfall is equitably distributed throughout the growing season but decreases markedly during the fall or harvesting period.

In addition to the adequate supply of moisture, experience has shown that the sugar-beet crop is favored by a long and moderately cool growing season. All the factories operating in the North Central States are located between the isotherms of 67° and 72° F. mean summer temperature (May to September, inclusive), as shown by the accompanying map. (Fig. 1.)

While it is possible to grow the sugar-beet crop under other temperature and climatic conditions than those indicated, the results so far have not been sufficiently satisfactory to lead to its becoming permanently established in many districts outside of the zone designated. The mere fact that a district or area may be included between these isotherms does not definitely guarantee that sugar beets can be

grown there successfully or profitably. Even though the seasonal temperature and the annual rainfall and its distribution are favorable, the soil types and many other factors, some economic, have restricted the localities within the humid area where the crop can be successfully grown.

In the localities where the sugar-beet crop apparently is permanently established in the humid area, there is reasonable certainty of warm days and fairly cool nights during the growing season. This favors the rapid growth of the crop. Since the sugar-beet root is a vegetative structure, growth will continue as long as temperature and moisture conditions are favorable, and the longer the period during which growth can be continued the higher will be the tonnage. However, the value of the crop depends largely upon the sucrose content, and its storage is not favorably influenced by conditions that permit a continuation of vegetative growth. As the nights become cooler in the latter part of the season, although the

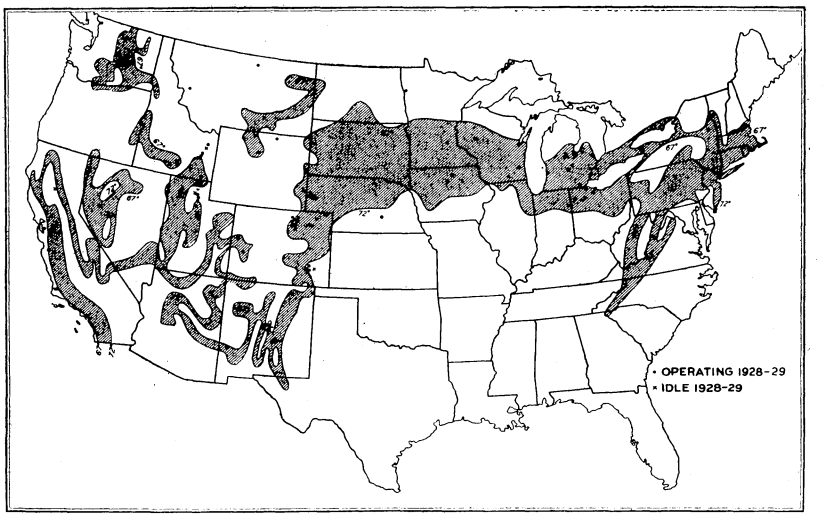

FIGURE 1.—Map showing location of beet-sugar factories

days still remain warm and sunny, vegetative growth is retarded and the storage of sucrose in the root is accelerated.

In general, then, the climatic conditions that favor the production of sugar beets in the humid area are found where the rainfall is distributed throughout the growing period so that growth can be continuous and rapid, where the fall months are sufficiently dry to check the vegetative growth to some extent but not sufficiently dry to stop it altogether, where the summer temperatures are such that growth is favored, and where the fall temperatures aid in checking vegetative growth and promote the storing of sucrose.

SOIL REQUIREMENTS

It is difficult to make any definite statement regarding the type of soil upon which to grow the sugar beets, for they have a very wide adaptation and may be grown upon either mineral or organic

soils. With the mineral soils upon which the greater acreage is grown, the higher and more satisfactory yields are generally secured on the heavier types, such as loams, silt loams, clay loams, and clays, though satisfactory yields have often been obtained upon sandy loams and in some instances upon the still lighter-textured sandy soils. With the organic soils or mucks the yield depends very largely upon the characteristics of the soil. The heavier types of mineral soil are generally better suited to the production of the sugar-beet crop than the lighter soils, and the location of sugar factories in the humid area in general conforms to this broad principle.

Soil type alone is not the determining factor in the production of a satisfactory yield. For successful production of sugar beets

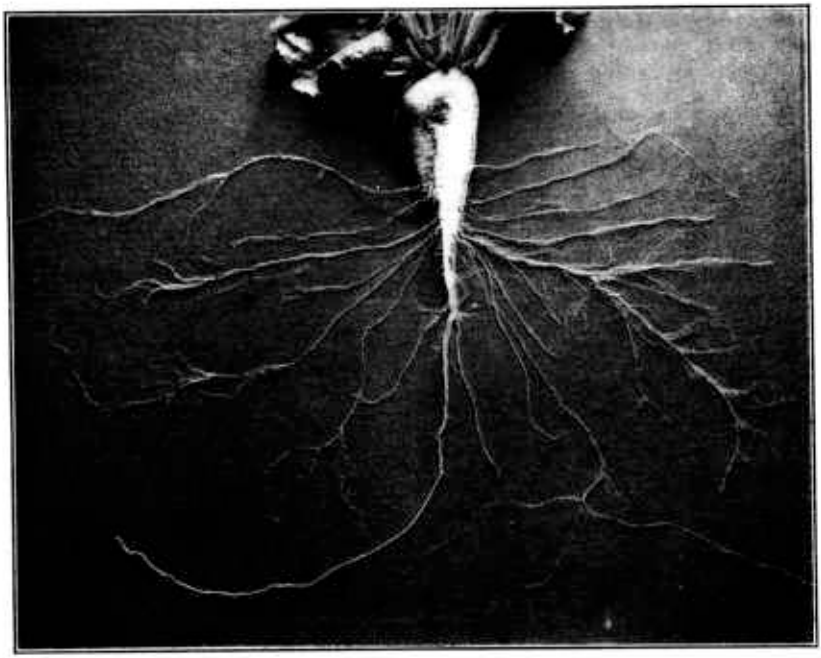

FIGURE 2.—Wide-spreading and deep-penetrating root system of a 3-months'-old sugar beet. The soil had been washed away from the growing plant to avoid breaking the roots

the soil should have good depth, a fairly high organic content (the mucks are characterized by their extremely high organic content), adequate drainage, high moisture-holding capacity, and a favorable reaction.

The sugar-beet plant sends its taproot deep into the soil (fig. 2), and any structure that limits the normal and usual depth to which the root can penetrate decreases the volume of soil upon which the taproot and its numerous small feeding roots may draw for the mineral elements and moisture used in the growth of the plant. Practically all the soils upon which high yields are regularly produced are found to have a depth of at least 3 feet before there is any change in the structure that prevents the penetration of the roots. If the depth of root penetration is limited by soil structures, such

as hardpan or plowsole, or by a high water table, the roots produced under such conditions are very likely to be ill-shaped. On the other hand, if the soil has sufficient depth, the tendency of the sugar-beet plant is to send its roots straight down for a considerable distance. Thus where there is sufficient depth to the soil to allow deep penetration of the taproot the roots harvested will be long and tapering (fig. 3) and of considerably better type than those grown with a high water table (fig. 4), or other unfavorable subsoil condition.

FIGURE 3.—A sugar beet of excellent form

Although it is sometimes possible to secure a fair tonnage from a field where soil structures or drainage conditions prevent the beets from making their normal growth of well-shaped roots, ill-shaped roots materially increase the tailings loss at the factory, and higher yields of more desirably shaped roots could be obtained if the hardpan or plowsole were broken up, or the unsuitable drainage condition corrected.

For the production of satisfactory yields the mineral soils should have a fairly high content of organic matter, which is not only a source of some of the elements that the plant uses but is also a great factor in the retention of moisture and in influencing the state of tilth. The organic content of the mineral soils is maintained or increased by the use of green-manuring crops in the rotation or by the application of barnyard manure.

In the humid districts much more loss is occasioned by the lack of adequate drainage than is commonly supposed. Lack of drainage limits the depth to which the roots can penetrate and thus limits also the volume of soil upon which the crop can draw for the mineral and moisture supply for its growth. In an undrained soil the height of the water table usually varies according to the precipitation received. When a period of low precipitation occurs the water table will drop away from the comparatively shallow plant roots, and the crop will suffer from drought more quickly on such a soil than on a well-drained soil where the roots have penetrated to a greater depth. Conversely, in periods of high precipitation more damage is sustained on the poorly drained soil, as the water table rises more rapidly than in one that is adequately drained. Instances are found of fields that give good yields where there is a high but

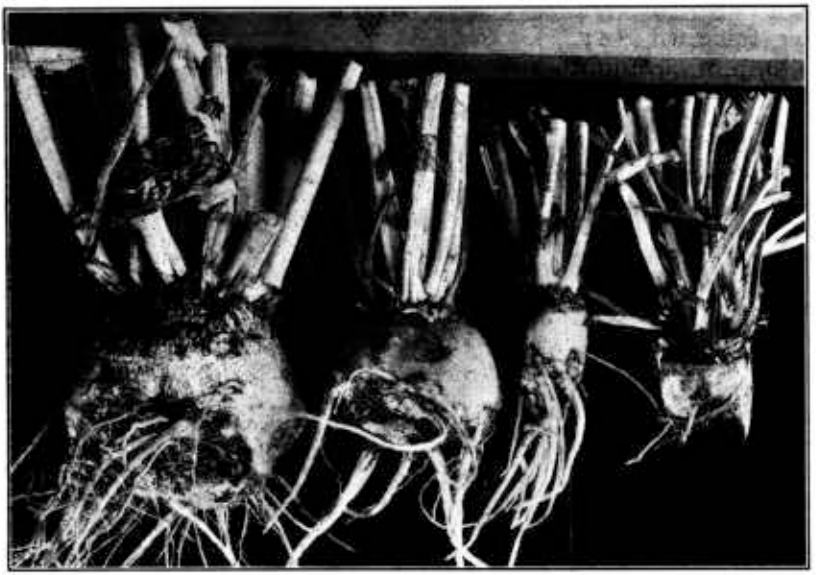

FIGURE 4.—Sugar beets of undesirable shape

constant water table. These yields are possible because of the fact that the constant water table keeps sufficient moisture for continuous growth always within the reach of the plant roots.

The sugar-beet crop, in order to do its best, must grow continuously from the time it starts until within a short time before harvest. In the humid area, where the crop is produced under natural precipitation, it is inevitable that periods of drought occur. If the amount of moisture held within the soil is insufficient to maintain the crop at a high rate of growth during the drought period, growth lags, and the yield is correspondingly reduced. It is during these periods of drought that the heavier types of mineral soil and the organic soils with their higher moisture-holding capacity have a great advantage over the lighter types of mineral soils. It is a common sight to see a sandy spot in a field, or a spot with a sandy subsoil, outlined by the wilting during the middle of the day of all

the beets within the area, while the plants on the adjacent heavier soils show no signs of suffering from drought. The organic matter in the soil, the humus, greatly increases its moisture-holding capacity, and the sugar-beet crop, therefore, seldom suffers from drought as quickly on soils that are high in organic matter as on soils that are low in this important soil constituent. It has been determined that the quantity of water necessary to produce 1 pound of vegetable matter on a productive soil is less than the quantity necessary to produce a pound of vegetable matter on a poor soil. Upon a productive soil the crop is better able to withstand a drought than upon an unproductive one. However, the total quantity of water required to produce the higher yield on the productive soil will be more than that required to produce the smaller yield on the poorer soil.

For the best results with the sugar-beet crop it is believed that the soil reaction should be slightly alkaline. The sugar-beet plant is apparently rather tolerant in this respect, for satisfactory yields have often been obtained upon soils with a slightly acid or even an acid reaction. Field observations and tests indicate that it is much easier to secure and keep a full stand on a soil that has a neutral or an alkaline reaction. If it is possible to secure a good stand of alfalfa or sweetclover on a field where the sugar beets are to be grown, it may be assumed that the soil reaction is suitable for sugar beets. If it is difficult or impossible to secure a good stand of alfalfa or sweetclover where the sugar beets are to be grown, it is quite probable that the soil is sour, and an application of lime is recommended before the sugar beets are planted. On soils where the drainage is poor or where water stands for any considerable length of time during any part of the year, the reaction of the soil is often found to be unfavorable to the sugar-beet crop. Better stands and yields are obtained after a sufficient quantity of lime is applied to bring about the right reaction. In applying lime to the soil intended for sugar-beet culture there is little danger of applying too much and thereby injuring the crop. The application of more lime than necessary to create a favorable reaction is probably a waste of labor and material, since the benefit derived from the surplus is usually relatively insignificant as compared to the cost.

ROTATIONS

The desirability of rotating sugar beets with other crops depends upon several factors. Rotation is not an end in itself but merely a means to an end, and unless some definite benefit is derived there is no practical or logical basis for it. The main reasons for the generally accepted practice of rotation in the case of sugar-beet growing are:

Proper rotation permits the economical utilization of the condition of the soil as left by the preceding crop.

Proper rotation increases the profits by an elimination of work.

Proper rotation protects the crop to a very considerable extent against insect pests, weeds, and plant diseases.

Nearly every properly planned rotation upon a mineral soil will include one crop that adds organic matter to the soil. This may be a legume, but other crops are often used for this purpose. If a leguminous crop is used, the double purpose of adding organic mat-

ter and nitrogen to the soil is accomplished at one time. Of the various green-manuring crops, red clover, sweetclover, and alfalfa are probably the most important. These are sometimes grown immediately preceding the sugar beet and sometimes as the second crop previous to the sugar beets. There is some objection to using either alfalfa or sweetclover immediately preceding the sugar beets, since both these crops are likely to leave the soil in a poor physical condition and the plants, which are difficult to eradicate, may persist and become weeds in the sugar-beet field. On this account many growers favor the use of a green manure as the second crop preceding the sugar beets, the intervening season giving ample time to eradicate any plants of the deep-rooted legume that may have persisted, as well as to reduce the soil to a desirable state of tilth. One other objection to using a green-manuring crop immediately preceding the sugar beets is that in some instances there is greater danger of insect injury. Cutworms and white grubs, as well as wireworms, are often found in grassy, clover sods, and if sugar beets are planted immediately following such a crop insect injury is likely to be sustained. Fall plowing in this case will reduce the danger of injury from white grubs and wireworms, or an intervening crop can be grown in case fall plowing can not be done.

In some rotations that have been very successful with sugar beets, heavy applications of barnyard manure are used in place of a green manure. The success of this practice depends to a large extent upon the quantity of manure that is available, as it requires relatively heavy applications to equal a heavy growth of a green-manuring crop in supplying organic matter.

The crop succession in a properly planned rotation will be such as to leave the soil as free from weeds as possible. This is a factor of great importance. In some places the impression has become established that the sugar-beet crop can be profitably used to clean up foul fields in preparation for other crops. On account of the intensive work which is normally given the sugar beet this is possible, but the net cost is likely to be far greater than is supposed on account of the low tonnage that is usually secured when this practice is followed. It is almost impossible to remove the weeds in a foul field quickly enough to prevent loss of yield by the weed competition, and it is practically impossible to clean up a foul field without losing an appreciable portion of the stand. The sugar beet is a cash crop, and every effort should be made to produce as high a yield at as low a cost as possible. The use of weed-free soil will eliminate work and secure higher yields, thus increasing the profit.

A properly planned rotation gives ample time between the removal of one crop and the planting of the next for thorough preparation of the soil. It has been demonstrated repeatedly that higher yields (1 ton or more) are obtained from the sugar beet upon fall-plowed than upon spring-plowed areas (Table 1), and therefore the preceding crop should be moved from the field early enough to permit fall preparation of the soil for sugar-beet growing. There are some rotations in use in which the soil is left in such excellent condition by the preceding crop that the growers have found it practicable to prepare the soil in the spring for the sugar beets by simply disking

and harrowing. This item alone, where comparable yields are obtainable, increases the profits.

TABLE 1.—*Influence of time of plowing on yield and sucrose content of sugar beets* [1]

Time of plowing	Commercial roots per acre	Yield per acre	Sucrose content	Estimated sugar per acre
	Number	*Tons*	*Per cent*	*Pounds*
Fall	20,433	14.48	14.06	4,073
Spring	19,439	13.37	14.11	3,775

[1] Each number in the table is the result of 1,080 determinations. These determinations were made on sugar beets growing on medium light soil.

Although it is impossible to give definite recommendations for all localities as to the exact crop sequences to use, or even the various crops to use in rotations, it is possible to mention several that have given satisfactory results. These are given in Table 2.

TABLE 2.—*Outline of typical rotations*

Rotation	First year	Second year	Third year	Fourth year	Fifth year	Sixth year
A	Sugar beets	Barley [1]	Clover	Beans		
B	do	Small grain [1]	do	Corn or potatoes.		
C	do	do	do	Corn, beans, or potatoes.	Small grain [1]	Clover.
D	do	Oats or barley.[1]	Alfalfa	Alfalfa	Alfalfa	Corn, beans, or potatoes.
E	do	Corn	Oats	Wheat [1]	Clover	
F	do	Small grain [1]	Clover	Corn	Beans	

[1] Seeded to the following leguminous crop.

PREPARATION OF THE SOIL

The first step in the actual preparation of the soil for the sugar-beet crop in the majority of cases is plowing, though in many localities growers follow the practice of thoroughly disking the soil first. (Fig. 5.) Disking cuts up any trash or material that might have been left on the soil by the preceding crop and makes it easier to turn under such material. It has the added advantage of thoroughly pulverizing the surface soil, so that the portion of the furrow slice that is turned down is already in a fine granular state, and no large openings are left at the bottom of the furrow. Consequently, a smaller number of diskings or rollings with a cultipacker are necessary to firm the soil sufficiently to make a good root and seed bed.

Whether the soil is to be plowed or not and the depth to which it should be plowed depends very largely upon the nature of the soil, the preceding crop, and the equipment available. Shallow plowing is easier and less expensive on all types of soil than deep plowing, but the results obtained with the sugar-beet crop are usually in favor of the deeper plowing. Results of a great many comparative tests

over a series of years at the Michigan Agricultural Experiment Station with different depths of spring plowings show decisively the advisibility of the deeper (8 to 10 inch) type of plowing. With the deep plowing the stand was better and the tonnage and the sugar per acre were increased.

Deep fall plowing, 8 or 10 inches, on the heavier mineral soils is entirely practicable, as the effect of the freezing and thawing in the fall, winter, and spring assists very materially in breaking up and mellowing the large lumps of earth that are turned up, and the later work of preparing a good root and seed bed is relatively easy. However, if the same soil is plowed to the same depth in the spring the preparation of a proper bed is much more difficult. On the other hand, if this type of soil is plowed from 6 to 8 inches deep in the spring less difficulty is encountered in preparing a satisfactory bed. With the lighter types, the soil may be plowed to the same depth in

FIGURE 5.—Disking, both before and after plowing, is an important factor in the preparation of the soil. Previous to plowing, the disk cuts up all trash and other materials left on the soil and makes it easier to cover them when plowing, as well as to fine the portion of the furrow slice that is turned down. After plowing, disking breaks up the clods and lumps and reduces the soil to a better condition

either the fall or the spring without encountering difficulties in preparing a good bed. However, there is one disadvantage connected with plowing some of the lighter types of soil in the fall, for the effect of the frost is often so great that the structure is entirely broken down, and the soil is nearly as compact in the spring as it was in the fall before plowing. With the mucks, plowing often renders them so loose that extreme difficulty is likely to be encountered in compacting them sufficiently to form a good root and seed bed. Under these conditions it is often advisable to omit plowing in the preparation of the soil for the crop.

Following the plowing, whether the soil is light or heavy and whether the plowing was done in the fall or in the spring, the soil is usually thoroughly disked. (Fig. 5.) The disk cuts up the larger pieces of the furrow slice that have not fallen apart and stirs the soil so that the finer and looser material has an opportunity to move downward and fill up the crevices and holes between

the larger lumps and between the furrow slice and the bottom of the furrow. Following the disking, the cultipacker, or similar roller (fig. 6), is used to firm the soil and to crush lumps or clods that have been brought to the surface. With the organic soils heavy rollers are ordinarily used in place of the disk, and the cultipacker is used to firm the soil. Where the soil is not brought into the desired condition by the first set of operations the disking and rolling with a cultipacker are repeated as many times as is thought advisable. When the root bed has been thoroughly prepared the soil is sufficiently firm so that a person can walk upon it without sinking much over one-half inch, yet it has enough "give" to permit the roots to develop within the soil. If the root bed is too compact the beets have a tendency to rise out of the ground during the period of rapid development.

For the best possible condition for germination it is generally necessary to go over the surface with a smoothing harrow several

FIGURE 6.—Rolling. In the preparation of the seed bed, implements of this sort are used to crush clods and firm the soil

times. Usually the last harrowing should be at right angles to the direction in which the rows will run, so that the marks left by the harrow will not be confused with the drill marks, and the drilling can be accomplished more accurately. Many of the growers in localities where the sugar-beet crop is regularly grown wait a few days after the seed bed is prepared and then rework the soil before planting, in order to destroy all weeds that have started to grow.

The opinion that the sugar beet is "hard upon the soil" and that its culture decreases soil fertility more rapidly than is the case with other crops is sometimes expressed by farmers who otherwise are well informed. The results of chemical analyses to determine the amount of plant-food elements removed from the soil by a normal crop of sugar beets in comparison with normal yields of potatoes, wheat, corn, or beans show the sugar beet to be lowest in nitrogen and phosphoric-acid requirements of any of the crops mentioned, and slightly less in potash requirement than the potato. The chemi-

cal analyses therefore do not warrant the assumption that the sugar beet is a "soil robber."

However, it must not be expected that every soil can continue to produce good crops indefinitely without the use of fertilizers to replace the plant-food elements that have been removed from the soil, no matter what crop has been produced. In the humid area it is a general practice to apply a fertilizer of some kind to the soil for the production of the ordinary crops whether sugar beets are grown or not.

USE OF FERTILIZERS

Barnyard manure is perhaps the most common as well as the best fertilizer to use with the sugar-beet crop in almost all localities where sugar beets are grown in the humid area. Not only does the manure applied increase the organic content and moisture-holding capacity of the mineral soil, but it also adds some of the mineral elements that the plants use and improves the tilth of the soil as well. On organic soils or mucks the application of barnyard manure often increases the bacterial activity within the soil, thereby increasing its productiveness. The quantity of manure used is generally limited by the quantity that is produced on the farm and is seldom more than 10 tons per acre. The manure is not always applied immediately preceding the sugar-beet crop, for it is often found that greater benefit is derived by applying it for the cultivated crop preceding the sugar beets. This practice gives ample time for the manure to become incorporated within the soil, as well as opportunity to get rid of any weeds that may have been carried on to the field in the manure.

Commercial fertilizers are often used for the sugar-beet crop, but the mixture necessary and the quantity to apply for the best results depend upon the soil and the farming system followed. The quantity applied per acre varies widely, but the common practice is to apply one or two sacks of 125 pounds. This may be applied broadcast a short time before the crop is planted and harrowed into the soil, or it may be sown with the seed by using a drill with a fertilizer attachment. In some cases the growers prefer to broadcast part and sow the remainder with the seed.

The results secured from the use of commercial fertilizers vary widely. However, the value of the practice is not to be minimized, for the profit obtained when the proper fertilizer is applied in an adequate quantity is usually considerable, and therefore the question of a possible increase in the profit from the crop by the use of commercial fertilizers is urged upon the attention of every grower.

In order to determine the effect of fertilizers of different formulas upon both tonnage and sugar production, cooperative [2] projects have been carried on with different growers in the sugar-beet districts in Michigan for several seasons.

In the case of the projects on the heavier soils, types that have been under cultivation for about 10 years and which had received applications of barnyard manure as well as having had green-manuring

[2] The experimental results here summarized are based upon the data obtained in tests carried on in cooperation with the Office of Soil Fertility, Bureau of Chemistry and Soils, U. S. Department of Agriculture.

crops plowed under, the formulas that gave the best results contained no nitrogen and were relatively high in phosphoric acid. The supply of nitrogen in the soil in this case had been maintained by the applications of manure and by plowing under the green manure, and the availability of the potash present in the soil had been increased by the organic acids liberated by the decomposing organic matter. In the case of the experiments with the lighter soil types where there had been no applications of manure and no green-manuring crops turned under, the formulas that gave the best results contained relatively large amounts of nitrogen, were high in phosphoric acid, and contained less potash. The results of these tests with two soil types will serve to illustrate the fact that variations in the formula are necessary for different conditions both as to soil type and farming practices. If the farming practices, through the application of manure and the plowing under of green-manuring crops, maintain the organic matter and nitrogen in the soil to a high point, the fertilizer necessary to secure the best results will be different from that necessary where the organic matter and nitrogen content have both been decreased through poor farming practices.

Experimental work indicates that poor returns are obtained and that actual loss may result from applying a fertilizer that does not supply the elements that are deficient in the soil. The figures that have been obtained also show that fertilizers have an appreciable effect upon the quality of the sugar beets, though this effect is less pronounced than their effect upon the yield.

From specific consideration of the field in question, from experience in the response of other crops to the fertilizer elements, and by direct comparison with results from local experiments the grower should determine the appropriate fertilizer treatment to apply.

MACHINERY

For the best results with the sugar-beet crop the best type of machinery should be used in every operation, from the preparation of the soil until the crop is harvested and delivered. It is possible to grow sugar beets without any special machinery, but inasmuch as sugar beets are a root crop and are handled differently from other ordinary crops, the type of machinery that is best adapted for the other crops is not necessarily adapted to them.

The implements used in the preparation of the soil are of the general-purpose types. Thus it is not necessary to procure additional implements for this part of the work. But for the drilling, cultivating, and harvesting, specially-designed implements that fit the crop are needed. Various types of these implements, which serve the crop requirements well, are on the market. Some of these are shown in Figures 7 and 8.

SUGAR-BEET SEED AND PLANTING PRACTICES

The sugar-beet seed as furnished to the grower is not a true seed like a grain of corn or wheat, but is a seed ball composed of the dried flower parts and the seed produced by each flower of a flower cluster. (Fig. 9.) When the beet seed matures, the flower parts dry and the

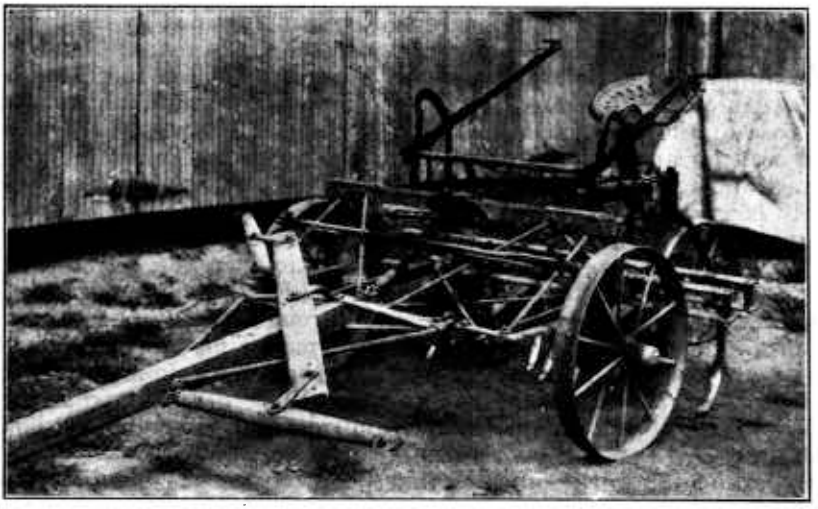

FIGURE 7.—An improved 2-row beet cultivator. In the humid area where fields are sometimes uneven because of the presence of dead furrows or back furrows, a 2-row cultivator stirs the surface of the soil more evenly than a wider machine. Where the surface of the soil is level or even, the 2-row cultivator does not do any better work than the wider machine and is also slower

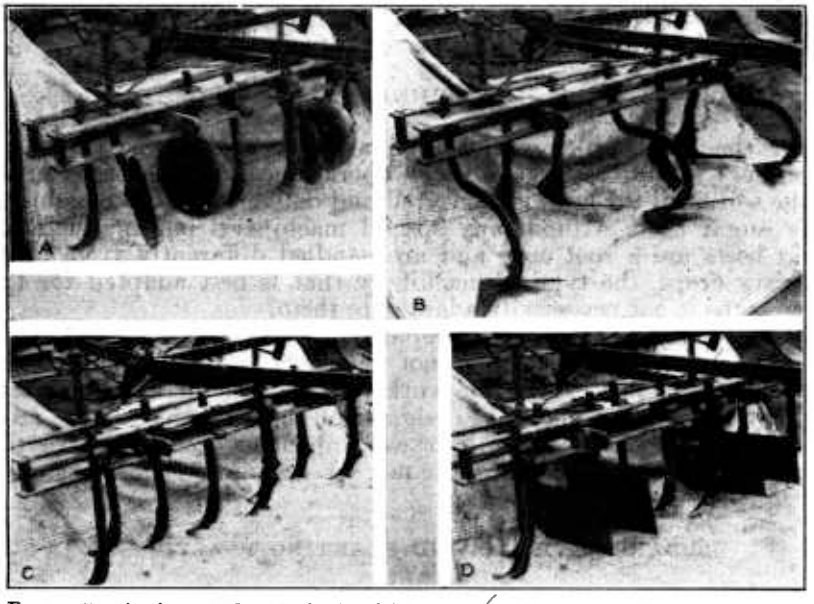

FIGURE 8.—An improved sugar-beet cultivator equipped with a variety of tools to meet different conditions; A, The cultivator equipped with disks and narrow shovels; B, equipped with knives and duckfeet; C, equipped with shovels only; and D, equipped with shields and shovels

seed or germ is held firmly within them. If two or more flowers grow in a cluster, as they usually do, the entire cluster sticks firmly together, and the seed ball resulting consists of all the flowers in the cluster together with the seed produced by each flower. Thus, when the seeds germinate, from 1 to 7 or 8 seedlings may emerge from a single seed ball. The seed balls vary greatly in size on account of the number of flowers that united to form the ball, but apparently this has no relation to the vigor of the seeds, for practically the same results in yield and in sugar per acre were obtained when seed balls of different sizes were planted. However, the number of seed balls dropped per foot in the row by the drill will be materially affected by their average size. In the writer's tests the same drill set was used with the seed balls of the different sizes and approximately the

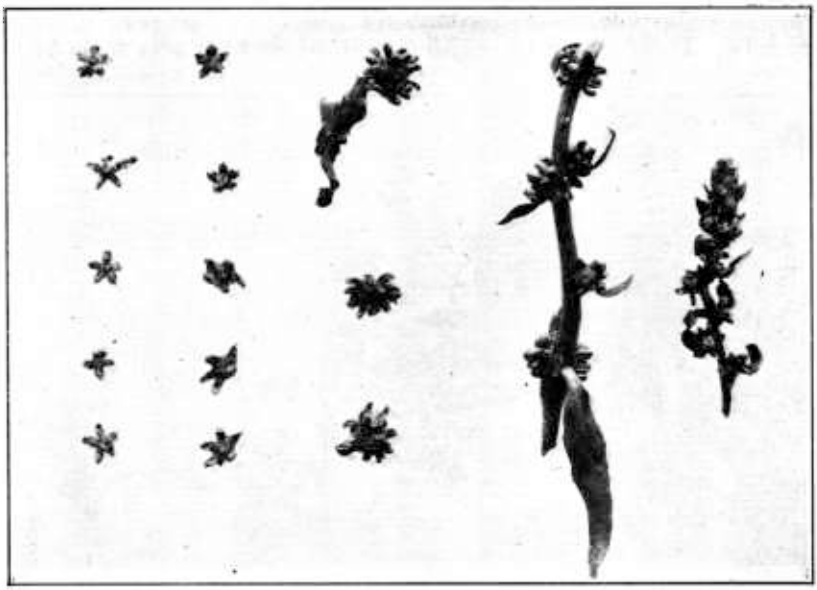

FIGURE 9.—Sugar-beet flowers, flower clusters, and spikelets with clusters, showing how the sugar-beet seed balls develop

same quantity of seed planted, but because of the difference in size more of the small seed balls were planted than of the larger sizes.

Practically all of the sugar-beet seed that is used in the United States at the present time is imported from Europe. Inasmuch as the sugar-beet crop is grown under contract for the beet-sugar factories and the contract usually stipulates that the seed used will be that furnished by the sugar company, the growers have very little to do with its selection or purchase. The sugar companies realize the necessity of furnishing a high-grade seed and make every effort to provide seed that will give the best results. Many of them conduct test fields in which the various brands of commercial seed are grown in order to determine their relative merit.

The sugar-beet crop is an intertilled one, and the seed is planted in rows so that intertillage is possible. For this purpose drills of

various makes are used. Figure 10 shows a common type. The space between rows used in the humid zone varies from 20 to 22 inches, to as high as 28 inches, with probably the greater portion of the crop being produced in rows 24 inches apart. Many of the growers prefer the wider spacing, as the crop is much more easily worked than when the rows are closer together. In some instances the seed is planted with an ordinary grain drill in which every third hole is left open. This spaces the rows according to the fixed adjustment of the drill. In districts where the bean crop is important, sugar beets are often planted and tended with the same tools that are used for the bean crop. Since the usual space between rows for beans is 28 inches, the sugar beets are often planted in rows of that interval.

The quantity of seed to use per acre for the best results depends upon the climatic and soil conditions and spacing of rows. In general the sugar companies recommend from 15 to 20 pounds of seed per acre. If the standard is 17.5 pounds of seed per acre for a 24-inch

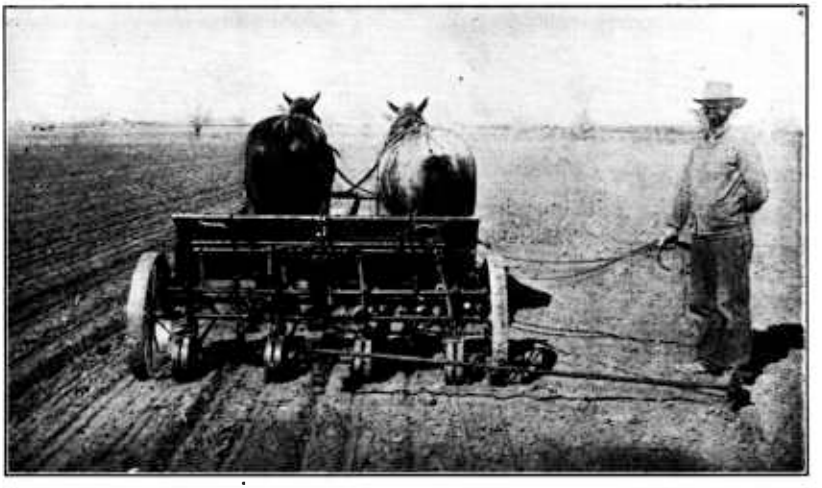

FIGURE 10.—A common type of drill used in planting sugar-beet seed in the humid area. This drill can be adjusted for rows of different widths

row, the equivalent for a 20-inch row would be 21 pounds and for a 28-inch row would be 15 pounds. Experiments conducted at the Michigan Agricultural Experiment Station showed an appreciable difference in yield in favor of 17.5 pounds of seed to the acre when 10 and 17.5 pounds of seed used in 24-inch rows were compared, but a further increase in the quantity of seed did not result in any increase in yield.

If the seed bed has been properly prepared and there is sufficient moisture in the soil for complete germination, the stand secured will be much thicker than can be carried through the season, but it is necessary to use the quantity of seed recommended, so that on soils that are poorly prepared (fig. 11) or under climatic conditions that do not favor germination, or where seedling diseases destroy a large number of seedlings the initial stand will be sufficiently thick so that the desired stand can be secured at thinning. For a good initial stand there should be one or more seedlings every 2 inches in the row.

Many failures in securing a stand of sugar beets have been blamed upon planting the seed either too shallow or too deep. Experiments conducted at the Michigan Agricultural Experiment Station indicate that there is a rather wide range in the depth to which the seed may be planted without materially affecting the stand secured, but the highest yields were obtained with seed planted 1 inch deep.

FIGURE 11.—Sugar-beet field showing vacant spaces where the surface soil has not been reduced to the proper seed-bed condition before planting

Since the soil should be warm enough for the seed to germinate readily after it is planted, and since there is considerable difference in soil temperatures at different depths early in the season, the early planting should be relatively shallow—from one-quarter to three-quarters of an inch. With the later plantings, when the soil has warmed to a greater depth and the surface has dried out, a depth of 1 to 1½ or even 2 inches is recommended, depending upon the soil and moisture conditions. With these later plantings, which are made

to the greater depths, when the surface soil is loose the seedlings will have little difficulty in breaking through the soil, but in case of hard rain before the seedlings come through there is danger of a crust forming which they can not break. To break up such a crust, cultipackers, weeders, and smoothing harrows have been successfully used. As long as the seedlings are still below the crust there is slight danger of destroying the stand, but if the leaves are held in the crust any disturbance of the crust is likely to break off the leaves and kill the seedlings. In such cases the grower must depend upon the slower germinating seeds for his stand or must reseed.

For the best development of the crop the sugar-beet plant should be given as long a season as possible in which to grow. It will continue to grow as long as conditions are favorable, and the rate of increase becomes greater as the plants become larger and have more foliage. Thus the growth in a single day in the latter part of the season is many times the gain made in a day or week early in the season. This increasing rate of growth is checked by climatic conditions or harvest in the fall, and in order to take the fullest advantage of the climatic conditions that permit the most rapid growth, early seeding is recommended. It has been demonstrated time and again in commercial fields and also on experimental plots that the highest yields are obtained from the earlier seedings. The differences in the yields obtained from early plantings do not represent the difference in the amount of growth made early in the season alone, but on the other hand do represent the differences in the gains made during the period of most rapid growth. However, it would be a mistake to slight the preparation of the seed bed or root bed in order to plant the crop a few days earlier than would otherwise be possible. Observations and experiments in the humid area indicate that the period in which the sugar-beet crop should be planted extends from the middle of April to the middle of May.

THINNING

Because of the fact that the seeds can not be planted singly, being contained within the seed balls, and as an excess of seed is used, the initial stand is usually much thicker than can be carried through the season, and it is desirable therefore that the seedlings be thinned to a proper stand before there is much competition among them. An experiment carried on at the Michigan Agricultural Experiment Station in which the seedlings were thinned at weekly intervals from the time the crop "rowed through"[3] until the end of the seventh week thereafter furnishes some information as to the best time to thin. The results showed a decided decrease in yield for each week's delay in thinning after the end of the second week. There are, however, certain conditions that may make it inadvisable to thin the beets between the first and third week after rowing through. In case of adverse weather conditions the beets may not reach the proper stage for thinning in the same length of time that they did in this experiment where the growing conditions were comparatively favorable. In fields where seedling diseases are killing a large number of

[3] The term "rowed through" is used to indicate the condition when the row of beet seedlings can be followed for several hundred feet with the eye. This stage, when the true leaves are just starting, is taken as a basis, because it is the earliest stage at which thinning can be done.

plants, it is a very good plan to wait until the disease is brought under control or has run its course before thinning.

It is not always possible to thin a commercial field of beets at just the proper time, on account of labor conditions. Growers usually contract with the sugar company for the labor necessary, and the companies make every effort to supply it at the proper time, but there are factors involved which make it very difficult at times to supply at once the amount of labor necessary.

At the time of thinning, some of the seedlings will be large and flourishing, while others may be small and spindling. In order to determine the influence that the comparative size of the seedlings may

FIGURE 12.—Blocking and thinning sugar beets. The beets are first blocked by striking through the row with a long-handled hoe, care being taken to leave small bunches of seedlings at about the proper intervals in the row. Following this, another person removes all the remaining weeds and the extra seedlings by hand

have on the yield and sugar production, records were obtained from adjacent plots on which the largest and the smallest seedlings were selected, respectively. The results obtained indicate that there is a considerable gain by selecting the larger plants.

Two distinct methods are commonly employed in thinning sugar beets. In one the row of seedlings is first blocked with a long-handled hoe (fig. 12), care being taken to leave a few seedlings standing undisturbed at about the proper intervals. The extra seedlings and all remaining weeds are then removed by hand. In the second method (fig. 13) the thinners are equipped with small, short-handled hoes, and all the work is completed at one operation.

SOIL SPACE AND THE SUGAR-BEET CROP

The individual sugar-beet plant should be given enough space to insure the best results from the crop as a whole. This is influenced by the productivity of the soil, date of planting, weather conditions, and other factors. This space may not coincide with the amount that will permit each plant to make its greatest development. If the same space is to be given a beet plant when grown in rows 20 inches apart as when grown in rows 28 inches apart, the thinning distance must necessarily be different. Beets thinned 14 inches apart in a 20-inch row will have the same amount of soil space per plant as those thinned 10 inches apart in a 28-inch row. The fact that the beets are a little more evenly distributed over the soil with the 14-inch thinning in the 20-inch row would probably give them an advantage over those grown 10 inches apart in 28-inch rows.

FIGURE 13.—Blocking and thinning sugar beets at one operation. Here each worker is equipped with a small, short-handled hoe which is used to cut out the spaces or to block the beets. The extra seedlings and the remaining weeds are then removed by hand

Among growers there is a great diversity of opinion as to the proper space to allow per plant in order to obtain the best results from the crop, individual preference ranging from 10-inch thinning to as high as 16-inch thinning with rows of any of the customary intervals.

The experimental work carried on so far in the humid area has shown that there is no "optimum" spacing, since in tests with various spacings ranging from an average of 4 inches to spacings of 20 inches in the row the tonnages obtained were practically the same. As the spacing increased, the size of the roots increased accordingly. This is because the individual sugar-beet plant has the ability to increase in size and thus compensate to a large extent for the smaller number of beets per acre with the wider spacings. This development, however, apparently reaches a maximum, determined by the productiveness of the soil and the inherent ability of the beet to increase in size, beyond which the individual plant can not go if more than about 500 square inches of soil space are allowed. Ex-

tremely wide spacings, such as occur with skips or blank places in the row, result in very inefficient use of the growing area.

Under ordinary conditions a perfect stand after thinning is very seldom found in a commercial sugar-beet field. Even though the thinning is done with great care, there will be spaces within the row that increase the average distance between the beets and decrease the number of beets per acre. The results of definite experimental work have shown that there is a loss of tonnage as the stand becomes poorer. This is not so marked with deviations up to 20 per cent from a full stand, since the beets that remain increase in size and compensate to a large extent for the loss of stand; but as the stand becomes more and more irregular and the spaces between the beets become wider, the increase of size of the remaining beets can not compensate for the loss of stand. Furthermore, as the beets become larger their quality becomes poorer and their value per ton much less than the value of the smaller beets produced where the stand is more nearly complete. It is therefore recommended that every grower make an effort to secure and keep as nearly a complete stand as possible.

CULTIVATION

The cultivating period for the sugar-beet crop may be divided into two parts, the period prior to thinning and that following, but the amount of cultivation necessary in either period depends upon the type of soil, the content of organic matter, the thoroughness with which the soil has been prepared, the weeds that are present, rainfall, distance between rows, and other factors.

Since the sugar-beet seedlings are very small and can not break a crust, it is essential during the period of germination that any crust that forms be broken immediately. To accomplish this the cultipacker, corrugated roller, weeder, or smoothing harrow may be used. Later, after the seedlings have emerged and the rows can be seen, the ordinary beet cultivator and the cultipacker are generally used to break crusts and to keep the surface soil in condition. It is important during this period that this be done, as not only are many of the weeds destroyed but the aeration of the surface soil prevents to a large extent the loss of stand due to seedling diseases. It is during this period that thick seeding is an advantage, for the large number of seedlings in the row make the rows comparatively easy to follow.

In most of the sugar-beet growing districts it is customary to prepare the field for thinning by cultivating and rolling. (Fig. 14.) According to the terms of the labor contract, the hand laborers are to thin the beets and clean out all the weeds to a certain distance on both sides of the row. The cultivation given at this period outlines the space the hand labor is to clean out. After this cultivation it is customary to roll the field, so that the soil is less harsh to the hands and knees of the thinners. Very often the cultivations given at this period are not necessary from the standpoint of the crop but are given to enable the thinners to do better work. Again, after thinning, the fields are often rolled to force the soil back to the plants where the thinners have pulled it away with their hoes.

The number of cultivations given following thinning is determined by the rainfall and the weeds that start. Fewer cultivations

will be necessary on weed-free than on foul soil. These cultivations keep the soil between the rows in good condition and destroy the weeds. The period of cultivation is of indefinite length and terminates when the foliage covers the ground and the crop can be laid by. As the ground will be covered more quickly when the rows are close together, the crop can be laid by sooner than if the rows are farther apart. Types of cultivators have been developed which are fitted to the needs of the sugar-beet crop. (Fig. 15.)

Ordinarily the labor contract calls for two hoeings following thinning. Usually the same labor that did the thinning does this work. The object of the hoeing is to remove all weeds that have started in the row since thinning and that by reason of their location can not be reached with the cultivator, also to stir all the soil in the row that can not be stirred with the cultivator. (Fig. 16.) However, the

FIGURE 14.—Thinning a sugar-beet field that has first been cultivated and rolled. This preparation makes it possible for the thinners to do much better work

contract labor when hoeing usually removes the weeds and "doubles" only and gives slight attention to the stirring of the soil in the row.

HARVESTING

In order that the crop may make all the tonnage possible and store as much sucrose in the roots as conditions will permit, the harvest is deferred as long as it is safe to do so without danger of having the crop or part of it frozen in the ground. However, it is practically impossible to have all the crop harvested at a time that will permit every acre to make its highest tonnage, on account of labor conditions and other factors.

Ordinarily, samples are taken from the commercial fields at intervals from the first of September on, to determine the condition and quality of the crop. When the harvest season approaches harvest orders are given for those fields in which the sucrose content of the roots is sufficiently high to make extraction profitable. When the harvest order is given the grower is required to harvest and deliver

his tonnage at the time specified. This is necessary, as the supply of beets must be such that the operation of the factory will be continuous. If too many beets are delivered while the weather is still

FIGURE 15.—An implement that cultivates four rows at once, thus saving considerable time in this operation

comparatively warm, there is great danger from loss by deterioration of the roots in the bins or piles. The fresher the beets are when sliced, the smaller the loss between the field and the factory.

FIGURE 16.—Following thinning, the beets are usually hoed twice to remove all weeds that have started within the row, as well as the extra beets that were missed at thinning

In harvesting, the grower lifts the beets with an implement that is designed to loosen the beet roots in the soil. (Fig. 17.) After lifting, the beets are sometimes pulled from the ground by hand, knocked together to remove the adhering soil, and then thrown into

FIGURE 17.—A type of riding lifter in which the weight of the implement is kept from resting on the horses' necks by the two small front wheels

FIGURE 18.—Topping sugar beets after they have been pulled and thrown into windrows

windrows or piles so that the topping can be more easily done. (Fig. 18.) At other times the topper, using a knife with a hook on the end (fig. 19), pulls and tops the beets at one operation.

FIGURE 19.—Pulling and topping beets at one operation. The worker strikes the hook on the end of the knife into the crown of the beet, pulls the beet from the ground, grasps the root with the free hand, removes the hook from the crown, tops the beet, and throws the root toward the pile. The tops are allowed to lie where they fall. This method saves a small amount of time as compared to topping from windrows, but the beets usually carry a greater quantity of dirt

In topping, the crown of the beet is removed by cutting directly through the beet at the lowest leaf scar. This is essential, for the sucrose content of the crown is very low, and the purity of the juice in the crown is much lower than in the root. If the beets are not topped low enough the low sucrose content and the purity of the

FIGURE 20.—Beets loaded on a special beet bed ready for delivery to the station or factory. Wagon beds of this kind will hold from 2 to 4 tons

juice in the crown interfere very seriously with the extraction of the sugar.

After the beets are topped they are thrown into piles from which they are loaded into wagons (fig. 20) or trucks for delivery at the

station or the factory. In case it is impossible to deliver the beets within a few hours after topping and piling, the piles should be covered with leaves to prevent loss of weight due to loss of moisture. The longer the beets are to remain in the piles in the field, the more carefully they should be covered. (Fig. 21.) The loss of weight due to evaporation of moisture is not always realized by the growers. Under ordinary harvest conditions the shrinkage in uncovered piles may be more than 1 per cent a day. This shrinkage is strongly cut down by proper covering with beet tops or soil.

DISEASES

LEAF SPOT

Of the plant diseases that attack the foliage of the sugar-beet plant in the humid area, only one, the leaf spot or blight caused by the fungus *Cercospora beticola*, produces any appreciable damage. The fungus which causes this disease lives over winter in the material

FIGURE 21.—Piles of beets in the field covered to prevent loss of weight between harvest and delivery. The weight lost by uncovered piles is not always realized by the growers

left from the preceding beet crop, hence the advisability of rotating the sugar-beet crop with other crops. The conditions that favor this disease are warmth and high humidity. Conversely, the disease may make its appearance at any time after warm weather starts, but severe attacks are not likely to occur unless the weather conditions favor its development.

This disease, as its name implies, is characterized by small circular spots, seldom over one-eighth of an inch in diameter, produced upon the beet leaf. These spots appear first on the older leaves, but as the disease progresses they may be found upon all the leaves. When the older leaves are injured or destroyed the plant responds by putting out new foliage, which may also be destroyed before reaching full size. Thus, during a severe attack it is a race between the plant and the disease as to whether the plant can produce foliage faster than the disease can destroy it. (Fig. 22.) The effect of this disease in all severe cases is to increase the size and height of the crown of the sugar beet, and if the onset is early in the season there

is a loss in both tonnage and sucrose content, but if late in the season the loss is more noticeable in the sucrose content.

SEEDLING DISEASES AND ROOT ROT

Several organisms, the majority of which are present in practically all soils in the humid area, are able under favorable conditions to attack the roots of the sugar beet and to weaken or kill the plant. These organisms cause blackroot or damping off of the seedlings early in the season and are probably concerned in the root and crown rots later on. The development of these diseases is favored by conditions which are unfavorable to the sugar-beet plant, such as poor drainage and poor soil aeration. Conversely, conditions that are favorable to the development of the sugar-beet plant are unfavorable to the development of the diseases. Even though the organisms causing these diseases are present in all of the soils, they are held in check to a considerable extent by rotations in which the sugar-beet crop is not grown upon the same soil very frequently. Therefore, rotation is recommended. Cultivation to break up crusts and to give aeration to the surface soil early in the season while the plants are small is advisable.

FIGURE 22.—Sugar beet affected with leaf spot. This disease destroys the foliage, and the plant responds by putting out new leaves, which may be destroyed in turn. As this continues, the crown of the beet becomes higher and higher, but the root has very little opportunity to develop

INSECT ENEMIES[4]

Although there are, in the humid area, a number of insects or their larvae that feed upon the foliage or roots of the sugar beet, there are none that cause widespread damage. However, there are some that cause severe local damage, entire fields being ruined while adjacent fields show little or no injury. The most important of

[4] Prepared by W. H. White, Division of Truck-Crop Insects, Bureau of Entomology, U. S. Department of Agriculture.

these are cutworms, white grubs, wireworms, flea beetles, and grasshoppers.

Cutworms are the young or immature forms of medium-sized dark-colored moths or millers and are usually more destructive in fields that have not been cultivated the previous season, as many species of cutworm moths prefer to deposit their eggs in areas covered with vegetation. The principal damage by cutworms to the beet crop usually occurs early in the season when the plants are small. The cutworms may overwinter in the soil in the half-grown or nearly mature stage, and as soon as the weather begins to warm up in the spring they become active and feed upon any available vegetation. They feed at night, cutting off the rows of seedlings near the surface of the soil. During the day they hide beneath clods of earth or in the soil a slight depth below the surface.

Cutworms can be readily controlled by the use of a poisoned-bran bait composed of the following ingredients:

Dry bran	1 peck or 5 pounds.
White arsenic or Paris green	¼ pound.
Sirup or molasses	1 pint.
Water	3 or 4 quarts.

Or, in large quantities:

Dry bran	25 pounds.
White arsenic or Paris green	1 pound.
Sirup or molasses	2 quarts.
Water	15 to 20 quarts.

This bait should be prepared as follows:

(1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison in order to get a good kill. When making small quantities, the materials can be mixed in a bucket with a paddle, the poison being added slowly and the bran stirred at the same time. A still more effective way is to mix the poison and bran with the hands; however, since soluble arsenic is absorbed to a slight extent through the skin, there may be some objection to this method. If the hands have any cuts, scratches, or other wounds, do not put them into the bait. When making large quantities, the poison can be mixed with the bran on some flat smooth surface by using a shovel and rake in much the same way as in mixing concrete.

(2) Mix the sirup with the water.

(3) Put the poisoned bran in a bucket or washtub and gradually add the water-and-sirup solution, stirring slowly all the time. A large quantity of water added at one time will wash the poison from the bran, resulting in an uneven mixture.

Caution.—Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and arsenic so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency.

Either broadcast the poisoned bait or sow it by hand along the rows. Do this late in the evening so that the bait will not dry out to any great extent before the worms become active. From 10 to 15 pounds of the wet bait per acre is enough for one application. Where the bait is applied directly to the rows the smaller quantity will be sufficient. It may require two or three applications at 2-day intervals to rid the fields of the pest.

White grubs are the larvae or young of the common May beetles. Their normal habitat is in grasslands, but they will feed upon the

roots of other plants. There are many different kinds of white grubs, the majority of which require three years for full development. Therefore, any crop following a grass or clover sod the first, second, or third year is likely to suffer damage.

These pests are difficult to control, but much of the damage to the crop can be prevented by planting the beets in lands that have been under cultivation for at least two years. Fall plowing may also be practiced to advantage against these pests. The plowing should be done before the grubs go deep into the ground to pass the winter. This would be prior to October 10 in many sections.

Wireworms, the larvae or young of the click beetles, sometimes are destructive in certain lands. The kinds of wireworms that are found in the humid beet-growing area favor grasslands, and one species inhabits lands that are poorly drained. Wireworms require from three to four years to reach their full development, therefore the beet crop following sod may suffer damage over a period of years.

These pests are also difficult to control, but some relief may be obtained by following the methods suggested for white grubs; that is, fall plowing and avoiding planting beets on sod or grasslands. Low, wet, or sour lands should be drained, if possible, as the wireworm that inhabits such types of soil does not thrive in well-drained areas. Clover and buckwheat are not particularly susceptible to damage by wireworms, and these crops may be grown in areas which are heavily infested before the beet crop is planted.

Several kinds of flea beetles may attack the beet in the seedling stage by feeding upon the leaves. Under hot, dry conditions unfavorable to the proper growth of the crop these insects may destroy an entire stand in a comparatively short time. A method of combating these pests consists in rolling the fields during the middle of the day at a time when the flea beetles are most active and while the beets are somewhat wilted. This practice will crush many of the flea beetles and will cause little crop injury. Lime applied directly to the foliage of the plants in liberal quantities will act as a repellent to these pests. However, in order fully to protect the crop by the use of lime or other repellents it is necessary to cover all parts of the foliage, since the insect will seek the untreated portions of the plant for food.

Grasshoppers occasionally do considerable damage to the young crop, but they can be satisfactorily controlled by the use of a poisoned-bran bait. The poisoned bait for grasshoppers contains practically the same materials as that for cutworms and is prepared in like manner. The mash or bait should be scattered over the fields whenever the crop is threatened by a grasshopper attack.

BY-PRODUCTS

There are several by-products of the beet-sugar industry which are distinctly of agricultural significance. The most important of these is the forage supplied by the leaves and crowns that are left on the field when the crop is harvested. (Fig. 23.) Other by-products, such as beet pulp, molasses, and lime cakes, have also considerable agricultural value.[5]

[5] For further information on beet-top silage and other by-products of the sugar beet, see Farmers' Bulletin 1095, Beet-Top Silage and Other By-products of the Sugar Beet.

The weight of tops and crown produced in a field of sugar beets varies according to the yield of roots obtained. If the tops and crowns are weighed while still fresh it will often be found that the weight is equal to the weight of roots produced, but under certain conditions the weight may not be more than one-fourth of the weight of roots. Much of the weight is lost upon drying, but the dried tops are still palatable feed for cattle. From the ordinary beet crop, therefore, 5 to 8 tons of material suitable for forage can be assumed as an additional return from the beet crop.

The tops are usually utilized by pasturing cattle and sheep upon them in the field, or they may be siloed. If pastured, a considerable portion of the feeding value is lost by the tops being trampled into the ground, but this method of utilization eliminates the cost of

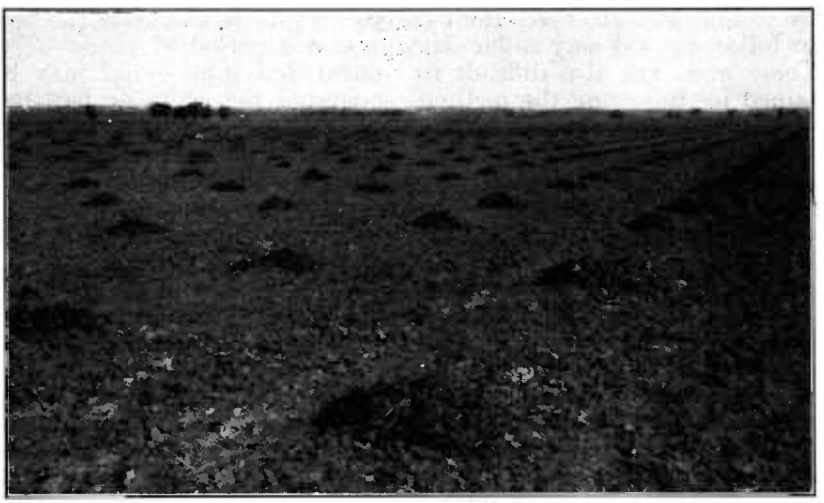

FIGURE 23.—Sugar-beet tops piled and ready to haul to the silo

handling. Since the crown contains salts that are very laxative, it is advisable, when the tops are to be pastured, to limit the time each day that the stock is allowed to feed upon them.

In siloing, whether the tops are to be placed in an ordinary silo or in a rick, it is advisable to mix straw or corn stover with the tops to absorb the excess moisture. If placed in an ordinary silo the mixing should be done as the material is put through the cutter. If the tops are siloed in a rick, they are not put through the cutter, and layers of straw and tops should alternate, each layer being about a foot thick, the whole being covered with a layer of straw upon which some earth is placed.

The feeding value of the beet-top silage, while probably varying considerably, is indicated by the comparison with corn silage shown in Table 3.

TABLE 3.—*Comparative analyses of beet-top and corn silage* [1]

Items of comparison	Moisture	Ash [2]	Crude protein	Crude fat	Crude fiber	Nitrogen free extract
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Beet-top silage [3]	64.36	9.25	2.87	0.44	5.46	17.62
Corn-top silage [4]	68.50	1.51	3.12	.80	6.53	20.54

[1] From U. S. Dept. Agr. Farmers' Bul. 1095, Beet-Top Silage and Other By-products of the Sugar Beet.
[2] Dirt gathered with the tops makes a high ash content.
[3] It is possible that silage produced from beet tops grown in other localities might show a higher or a lower feeding value.
[4] The analysis here given for corn silage is considerably higher than the generally accepted standard analysis for that product.

The root material from which the sugar has been extracted is known as pulp. This is sometimes placed in large circular silos near the factory, where it goes through fermentation before being sold to the growers. In a few cases it may be sold before fermenting. However, on account of the bulk and low value of the fresh or wet pulp, it is becoming more and more common for the pulp to be dried before being sold. In a good many cases the dried pulp is sold to manufacturers of stock feed instead of to the growers. The composition and feeding value of fresh and dried pulp in comparison with corn stover is given in Table 4.

TABLE 4.—*Composition of fresh and dried beet pulp and final molasses compared with corn stover* [1]

Items of comparison	Water	Ash	Crude protein	Crude fiber	Nitrogen free extract	Fat
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Corn stover, ears removed	9.4	5.8	5.9	30.7	46.6	1.6
Fresh beet pulp	90.7	.4	.9	2.1	5.7	.2
Dried beet pulp	8.2	3.5	8.9	18.9	59.6	.9
Final beet molasses	25.3	5.2	3.5	----------	66.0	----------

[1] Henry and Morrison, Feeds and Feeding, ed. 15, 1915.

The residue from the factory-recovery processes consisting of uncrystallizable sugar and various mineral constituents is called beet molasses. Beet molasses where available can be utilized for cattle feeding.

In the process of extracting the sugar from the sugar beet, a large amount of limestone is used, approximately 6 per cent of the weight of the roots sliced. This lime is finally discharged into settling basins near the factory, where it accumulates. Sometimes it is removed from the basins and heaped up in great piles. It has a considerable agricultural value, as its composition when dry (approximately 82 per cent calcium carbonate) compares very favorably with the ground limestone found on the market. This supply of lime cake, factory lime, or waste lime, as it is variously called, which is available at low cost is an important factor for soil amelioration in a community where soils need correction in reaction or where because of their tendency to become compacted the flocculating influence of lime is of value.

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